Front-end Electronics for Field Response Calibration System (LArFCS)

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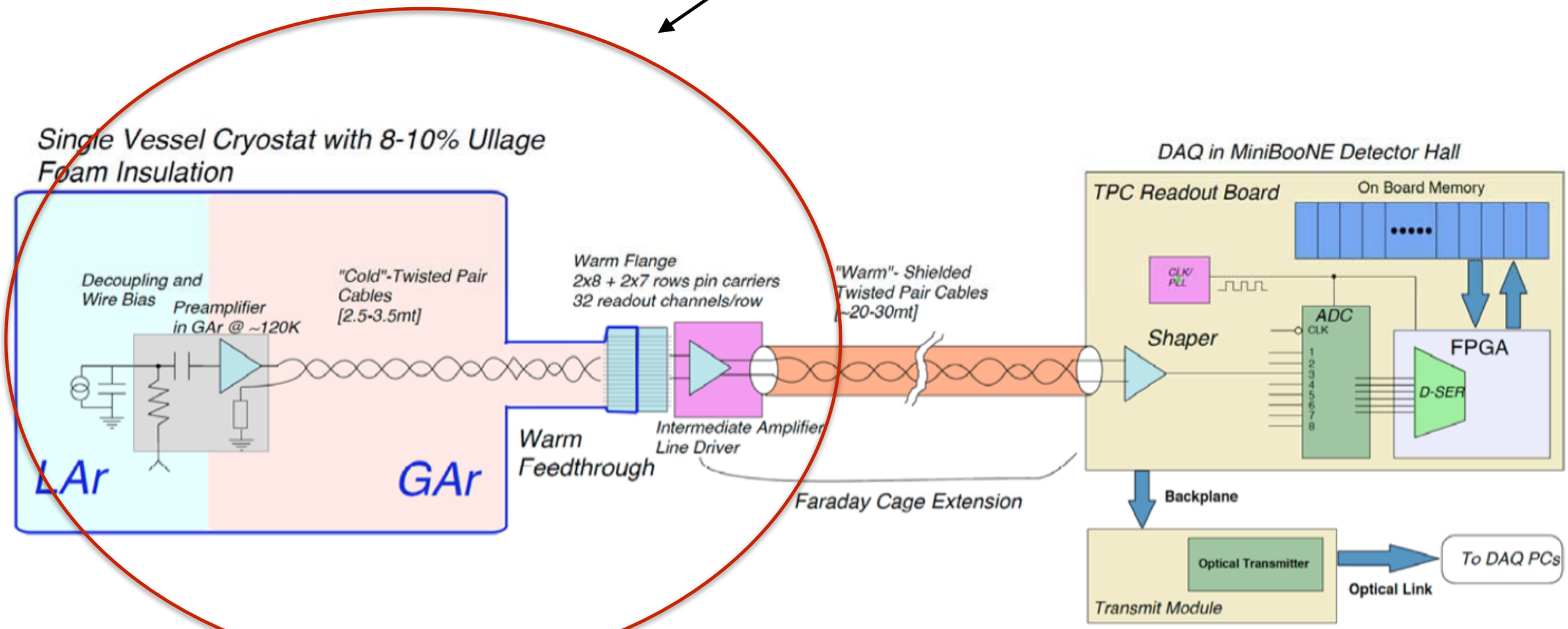
Introduction

* Plan is to have front-end electronics similar to uBooNE since it is already tested and all/(some) the designs/(parts) are available

* Plan to use as debugging tool for ProtoDUNE and SBND electronics in the future

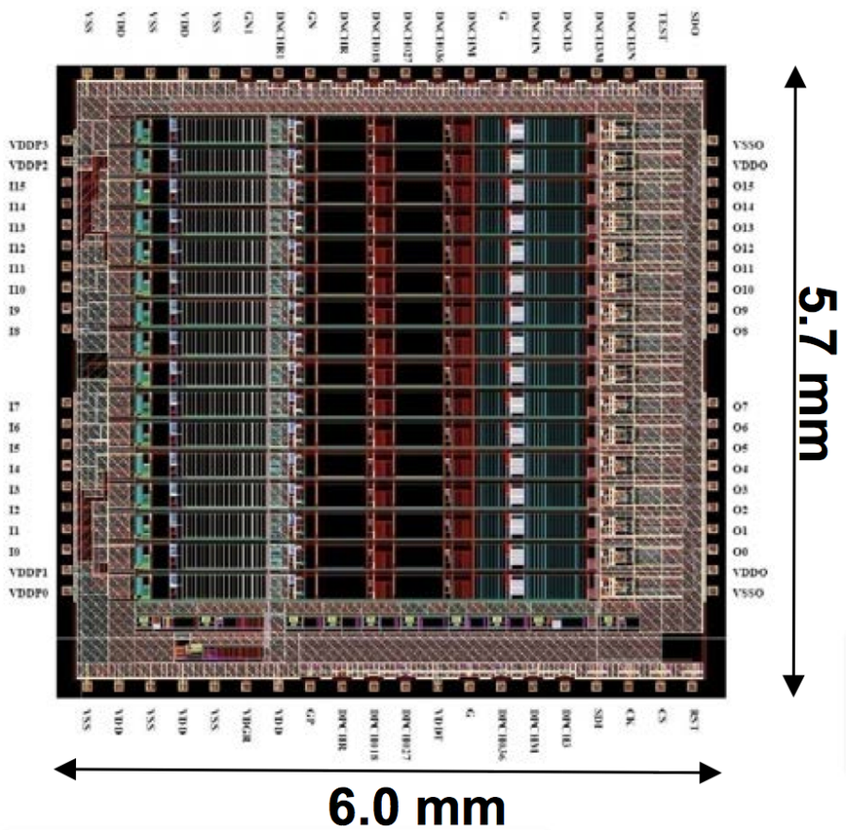
* Slides showing the brief overview of the scheme and current state of knowledge

Focus for this talk

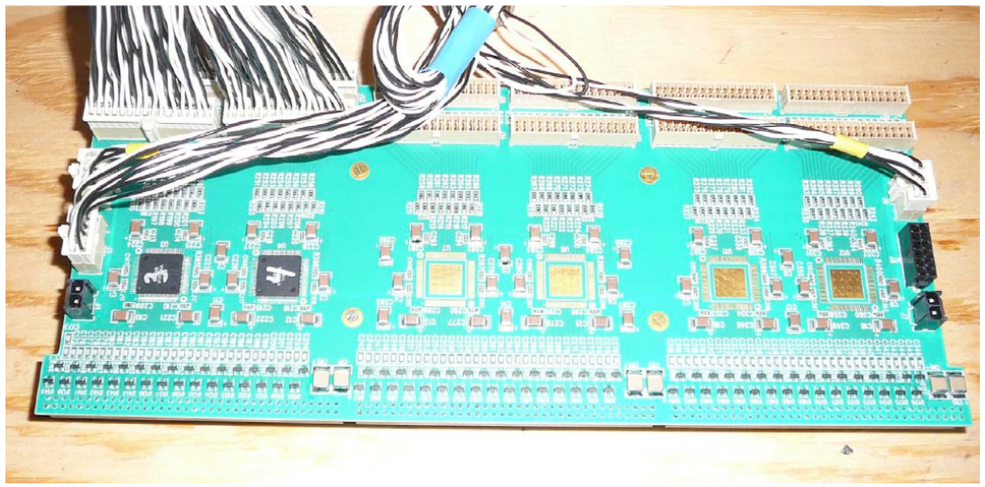


Electronics In the Cryostat (Cold)

CMOS FE ASIC



Cold MotherBoard with ASIC



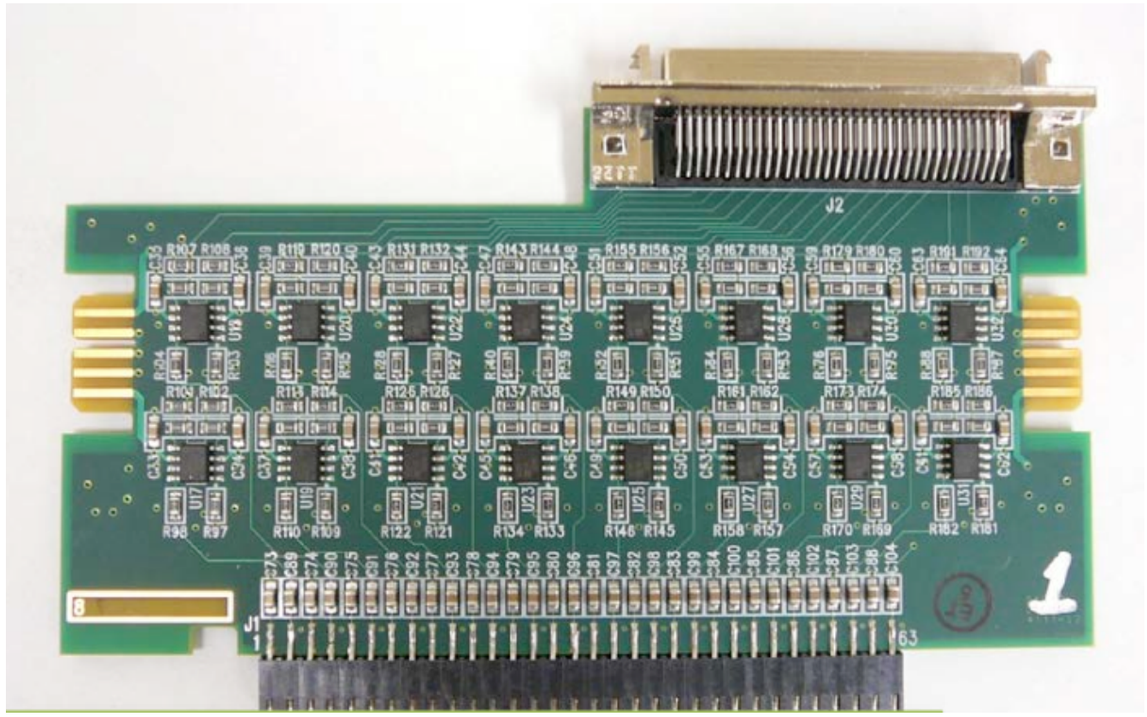
Cold Cable

* Cold MotherBoard (MB):
  - House FE ASICs
  - Provides detector signal interconnections
  - Provides ASIC control and monitoring signals, calibration network
  - Bias voltage distribution for wire planes
  - Two available designs from uBooNE TPC layout
    - Horizontal (48 U, 48 V, 96 Y channels)
    - Vertical (96 U or V channels)

FE ASIC Data Sheet: Docdb #4899

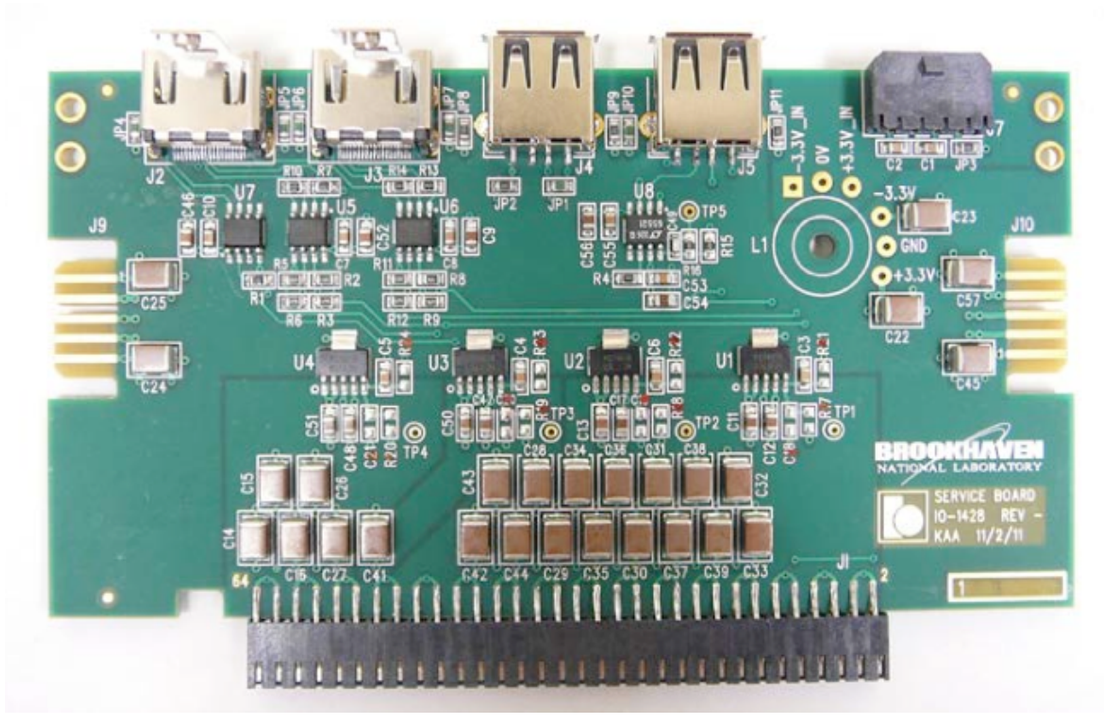
Electronics on the Cryostat (Warm)

Intermediate Amplifier



- Differential driver to improve noise immunity
- Provide a gain of ~12dB to detector signal for long distance (10-20m) transmission
- 32 channels per board
- Installed on top of signal feedthrough

Service Board (SB)

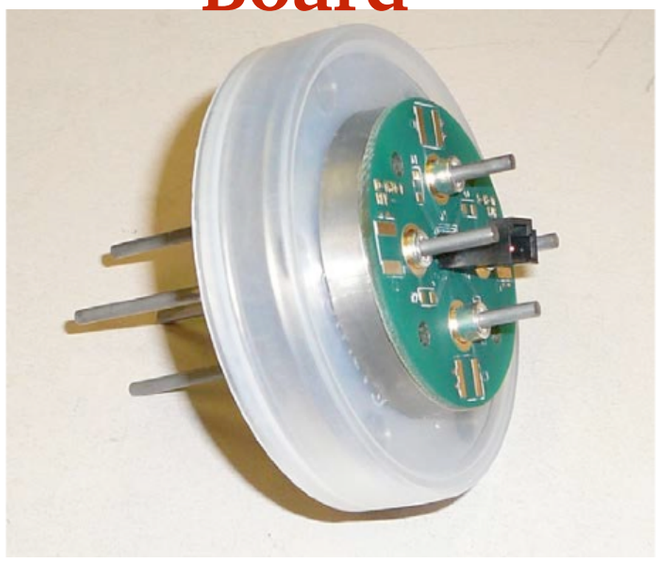


- Provide low voltage (+1.8V), control, monitoring and calibration
- Provide low voltage (± 3.3V) filtering and distribution to intermediate amplifier
- 1 SB can handle 2 MB
- Installed on top of the signal feedthrough

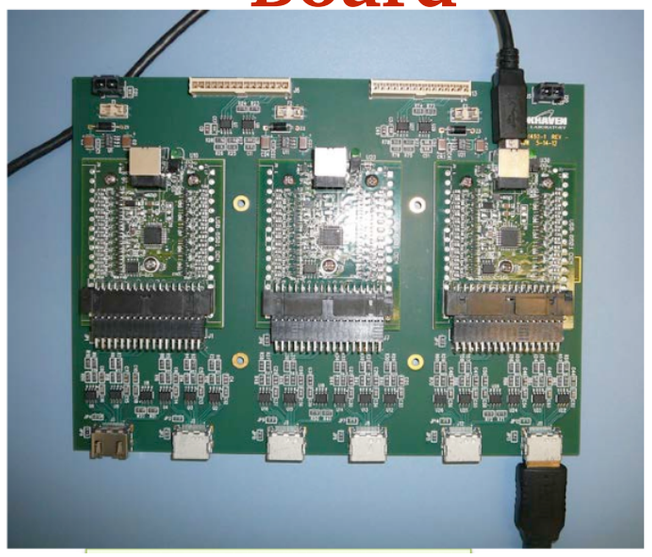
Electronics on the Cryostat (Warm)

Power Bus

Bias Voltage Filter Board



ASIC Configuration Board



Power Bus:

* Provide low voltage distribution from SB to intermediate amplifier
* Plugged onto the SB and intermediate amp. with card edge connectors

Bias Voltage Filter Board:

* Provide filtering of bias voltages on top of the bias voltage FT
* Board is attached to the bias voltage FT pins by on board sockets

ASIC Configuration Board:

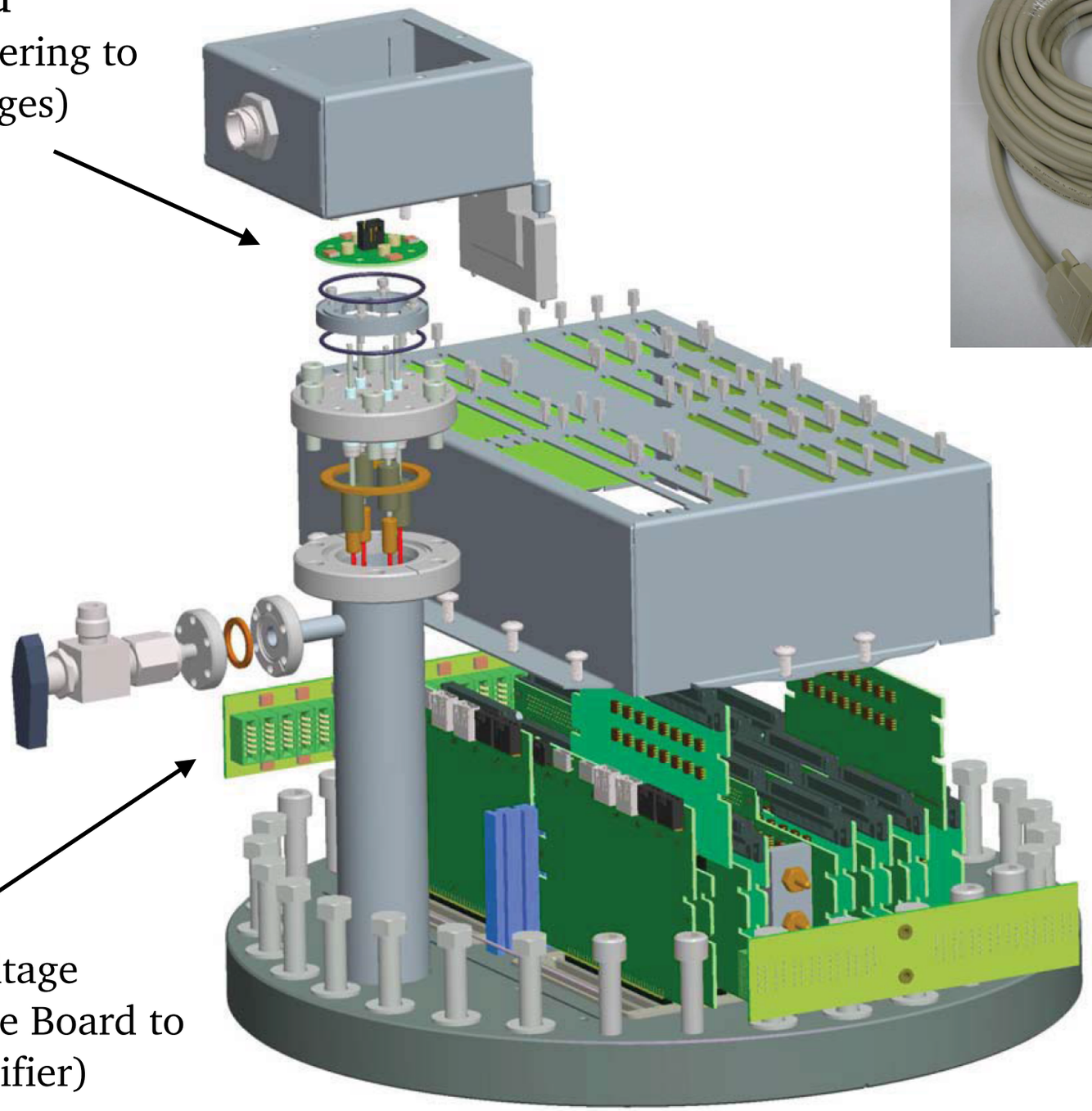
* Provide ASIC configuration and monitoring from NI USB to ASICs
* Convert single ended digital output to differential output signals
* Convert differential inout signal to single ended digital output
* 1 board communicates to 2 SBs (1FT)

Electronics on the Cryostat (Warm)

Warm Cable

Bias Voltage Filter Board
(Provides Filtering to bias voltages)

Signal FT Flange

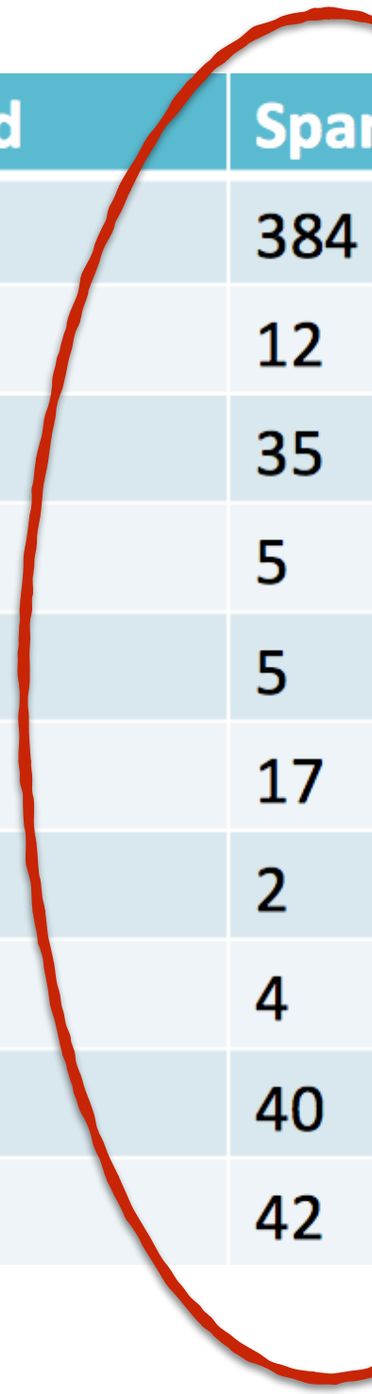


Power Bus
(Provides Low Voltage distribution from Service Board to Intermediate amplifier)

From uBooNE Production

H. Chen

Board	Needed	Spares	Total
CMOS ASIC	516	384	900
Cold Mother Board	50	12	62
Intermediate Amplifier	258	35	293
Service Board	22	5	27
ASIC Configuration Board	22	5	27
Receiver ADC board	130	17	147
Signal Feed-through	11	2	13
Faraday Box	11	4	15
Cold Cable	280	40	320
Warm Cable	258	42	300



Borrow from uBooNE/FNAL

Our Test-Stand Requirements

Parts list	Required	Availability
Channels	192	
CMOS ASIC	12	☑ uBooNE
Cold MotherBoard	1	☑ uBooNE
Intermediate Amplifier	6	☑ uBooNE
Service Board	1	☑ uBooNE
Power Bus	1	☑ uBooNE
ASIC Configuration Board	1	☑ uBooNE
Signal Feedthrough	1	☑ uBooNE
Faraday Box	1	☑ uBooNE
Cold Cables	6	☑ uBooNE
Warm Cables	6	☑ uBooNE
ASIC LV Power Supply	1	**Buy**
Wire Bias HV Power Supply	1	**Buy**

http://www.phy.bnl.gov/~jyoti/Front-End/frontend.html

Some Important Points

* Depending upon TPC and wire carrier boards design, we will use existing MB design.

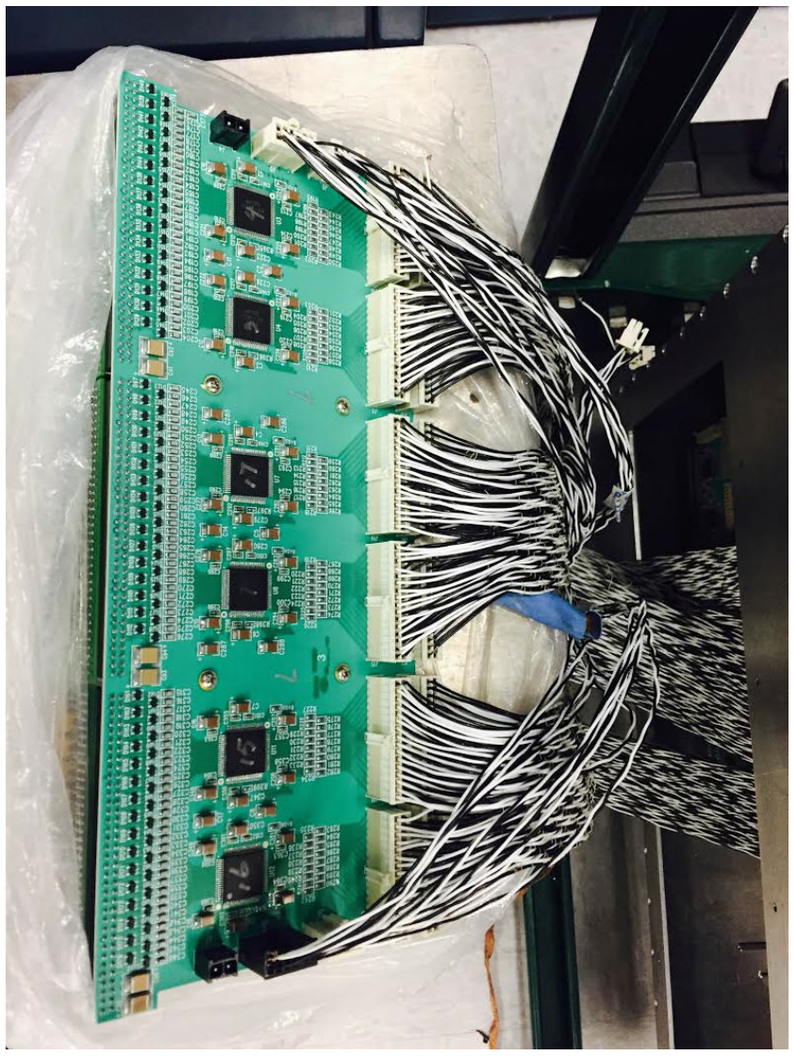
* Choose LV/HV power supplies in order to mitigate noise originating specially due to HV ripple as seen in uBooNE detector. Any bench top HV power supply from CAEN with ripple less than 100kHz is good for our use.

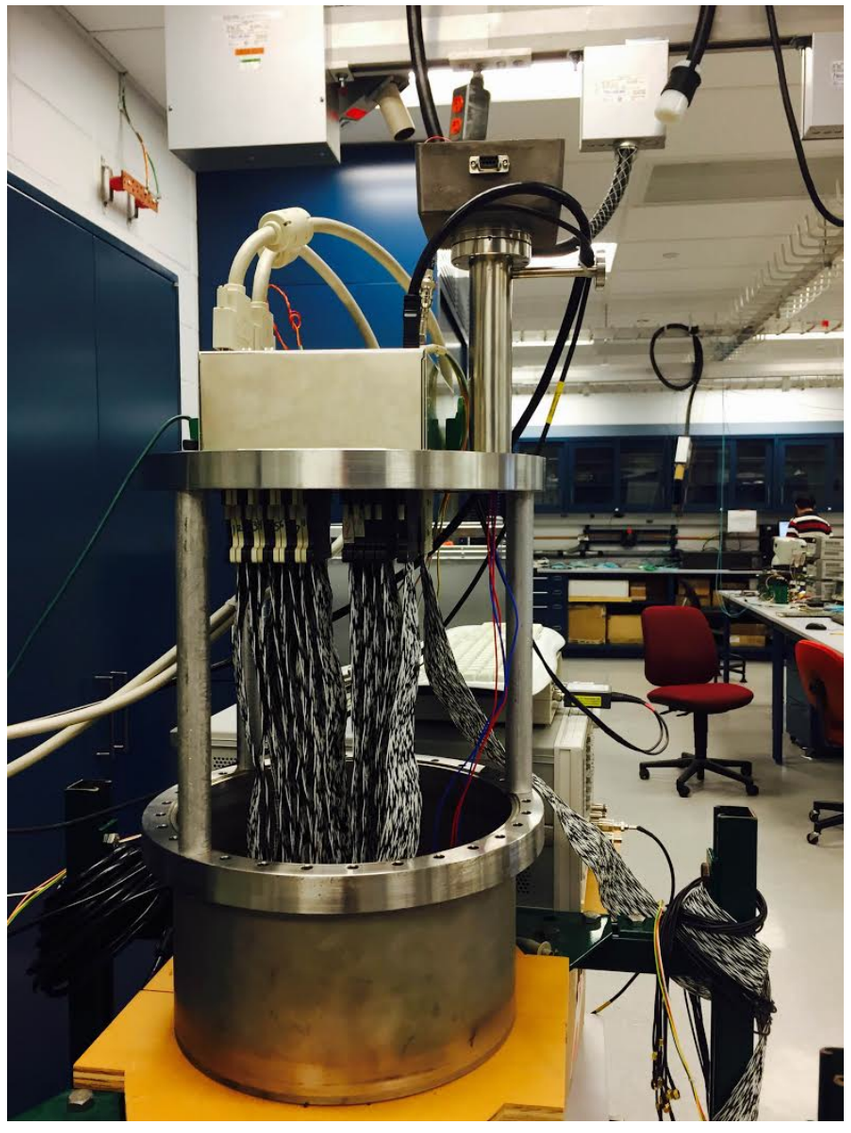
* Planning to perform electronics bench test once we arrange required components (borrowed/fabricated)

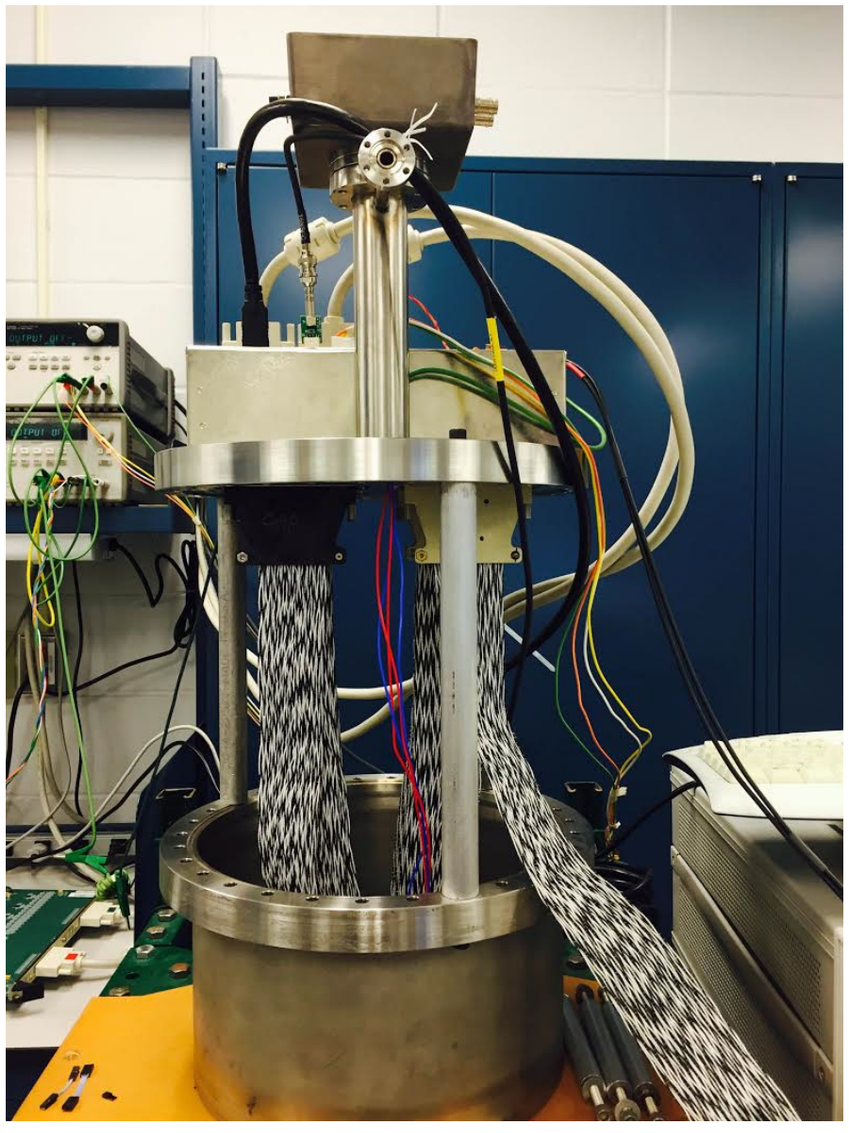
* Planning to use existing Chen's uBooNE test stand

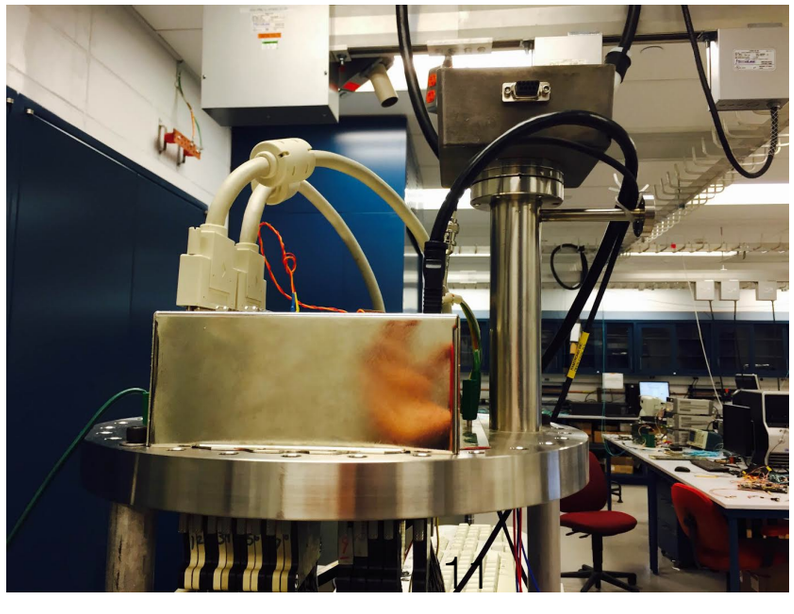
* Production plan for ProtoDUNE front end electronics is next year. In order to test ProtoDUNE electronics, we will need to replace all the components starting from wire carrier board to signal feedthrough

Local uBooNE Test Stand Pictures









Thanks!

Back-Up

1 ASIC = 16 channels

Horizontal:

1 MB = 48 U + 48 V + 96 Y = 192 channels

1 SB = 2 MB = 2*192 = 384 channels

1 FT = 2 SB (4 MB) = 2*384 = 768 channels

Vertical:

1 MB = 96 U or V = 96 channels

1 SB (A) = 3 MB = 3*96 = 288 channels

1 SB (B) = 4 MB = 4*96 = 384 channels

1 FT = 2SB = 3 MB + 4 MB = 288 + 384 = 672 channels

FT (No. 2 to 10) = 768*9 = 6912

FT (No. 1 & 11) = 2*672 = 1344

Total channels FT (1-11) = 6912+1344 = **8256 channels**

1 ASIC = 16 channels

Horizontal:

1 MB = 48 U + 48 V + 96 Y = 192 channels (192 cables ?)

48 U = (16*3) = 3 ASICs
48 V = (16*3) = 3 ASICs
96 Y = (16*6) = 6 ASICs

1 MB = 3 + 3 + 6 = 12 ASICs

Vertical:

1 MB = 96 U or V = 96 channels
1 MB = 6 ASICs

Total 516 ASICs (8256 channels)
Total 50 MBs

<u>Used later for mappings:</u>

1 FT = 4 MB

MB Labelled as A/B/C/D

1 FT = 2 SB

SB Labelled as 0/1

A/B -> 0 SB

C/D -> 1 SB

Estimated Cost - uBooNE

CMOS ASIC	Price/Board	Contingency Cost/Board	Contingency	Price of 5% of Full Detector w/o Contingency	Cost of Test Fixtures in Prototype Cycle 2	Price of Full Detector - 3.5 ft. w/o Contingency	Price of Full Detector - 3.5 ft w. 13.3% Spares
Parts	$ 77.87	$ 18.64	23.94%	$ 8,783.51	$ 4,000.00		
Fabrication	$ 25.00	$ 12.50	50.00%	$ 2,820.00	$ 2,000.00		
Assembly	$ 19.55	$ 4.89	25.00%	$ 2,205.24	$ 2,000.00		
Mask							$ 185,000.00
Wafer							$ 3,500.00
Run							$ 35,000.00
Packaging							$ 7,500.00
Total	$ 122.42	$ 36.03	29.43%	$ 13,808.75	$ 8,000.00		$ 231,000.00

Hor. MB	Price/Board	Contingency Cost/Board	Contingency	Price of 5% of Full Detector w/o Contingency	Price of 10% of Full Detector w/o Contingency	Price of Full Detector - 3.5 ft. w/o Contingency	Price of Full Detector - 3.5 ft w. 13.3% Spares
Parts	$ 263.20	$ 44.64	16.96%	$ 526.40	$ 1,052.80	$ 9,475.20	$ 10,735.40
Fabrication	$ 350.00	$ 87.50	25.00%	$ 2,000.00	$ 4,000.00	$ 12,600.00	$ 14,275.80
Assembly	$ 150.00	$ 37.50	25.00%	$ 300.00	$ 600.00	$ 5,400.00	$ 6,118.20
Total	$ 763.20	$ 169.64	22.23%	$ 2,826.40	$ 5,652.80	$ 27,475.20	$ 31,129.40

Intermediate Amplifier	Price/Board	Contingency Cost/Board	Contingency	Price of 5% of Full Detector w/o Contingency	Price of 10% of Full Detector w/o Contingency	Price of Full Detector - 3.5 ft. w/o Contingency	Price of Full Detector - 3.5 ft w. 13.3% Spares
Parts	$ 119.95	$ 22.69	18.92%	$ 1,691.30	$ 3,382.59	$ 30,947.10	$ 35,063.06
Fabrication	$ 75.00	$ 37.50	50.00%	$ 2,500.00	$ 5,000.00	$ 19,350.00	$ 22,252.50
Assembly	$ 75.00	$ 18.75	25.00%	$ 1,057.50	$ 2,115.00	$ 19,350.00	$ 22,252.50
Total	$ 269.95	$ 78.94	29.24%	$ 5,248.80	$ 10,497.59	$ 69,647.10	$ 79,568.06

ASIC Configuration Board	Price/Board	Contingency Cost/Board	Contingency	Price of 3 boards w/o Contingency	Price of 6 boards w/o Contingency	Price of Full Detector - 3.5 ft. w/o Contingency	Price of Full Detector - 3.5 ft w. 13.3% Spares
Parts	$ 337.50	$ 75.00	22.22%	$ 1,012.50	$ 2,025.00	$ 3,712.50	$ 4,206.26
Fabrication	$ 150.00	$ 75.00	50.00%	$ 1,750.00	$ 3,500.00	$ 1,650.00	$ 1,869.45
Assembly	$ 100.00	$ 50.00	50.00%	$ 300.00	$ 600.00	$ 1,100.00	$ 1,246.30
Total	$ 587.50	$ 200.00	34.04%	$ 3,062.50	$ 6,125.00	$ 6,462.50	$ 7,322.01
NI USB	$ 100.00						$ 1,500.00
Rack Packaging	$ 5,000.00						$ 5,000.00
SUM Production Total							$ 13,822.01

Estimated Cost - uBooNE

Cable & FT	Price/Cable	Contingency Cost/Board	Contingency		Price for 1 full feed-through w/o Contingency	Price of Full Detector - 3.5 ft. w/o Contingency	Price of Full Detector - 3.5 ft w. 13.3% Spares
Warm Cable	$ 215.75	$ 53.94	25.00%		$ 1,078.75	$ 55,663.50	$ 64,725.00
Cold Cable	$ 313.86	$ 78.47	25.00%		$ 1,569.30	$ 98,238.18	$ 109,851.00
Faraday Box	$ 500.00	$ 125.00	25.00%		$ 500.00	$ 5,500.00	$ 6,000.00
Feedthrough	$ 25,106.50	$ 6,276.63	25.00%		$ 25,106.50	$ 276,171.50	$ 301,278.00
Total	$ 26,136.11	$ 6,534.03	25.00%		$ 28,254.55		
SUM of Cables							$ 174,576.00

Service Board	Price/Board	Contingency Cost/Board	Contingency	Price of 3 boards w/o Contingency	Price of 6 boards w/o Contingency	Price of Full Detector - 3.5 ft. w/o Contingency	Price of Full Detector - 3.5 ft w. 13.3% Spares
Parts	$ 312.50	$ 75.00	24.00%	$ 937.50	$ 1,875.00	$ 10,312.50	$ 11,684.06
Fabrication	$ 125.00	$ 62.50	50.00%	$ 2,000.00	$ 4,000.00	$ 4,125.00	$ 4,673.63
Assembly	$ 150.00	$ 37.50	25.00%	$ 450.00	$ 900.00	$ 4,950.00	$ 5,608.35
Total	$ 587.50	$ 175.00	29.79%	$ 3,387.50	$ 6,775.00	$ 19,387.50	$ 21,966.04

	Feedthrough
14" Flange	$ 735.00
Pin Carriers	$ 8,800.00
Labor (Welding & Mac	$ 3,685.00
Bias Voltage FT	$ 2,000.00
Warm Cable	$ 9,886.50
Total	$ 25,106.50

Cold Cable Productior	Unit Price (/ft.)	Production Qty (ft.	Cost
Twisted Pair Cable	$ 0.33	75000	$ 24,375.00
Woven Cable	$ 2.06	2100	$ 4,326.00
Terminated Assembly	$ 134.00	350	$ 46,900.00
Terminal Mold	$ 5,000.00	1	$ 5,000.00
Terminal Material	$ 3,000.00	1	$ 3,000.00
Misc (Connector, Pin,	$ 75.00	350	$ 26,250.00
Total			$109,851.00
Cost per Cable			$ 313.86

Local uBooNE Test Stand Pictures